Ontario

Ministry of
Transportation and
Communications

MI-92

A REVIEW OF MTC CONCRETE COMPRESSIVE STRENGTH DATA FOR 1985

MATERIALS INFORMATION

ENGINEERING MATERIALS OFFICE

MI

A REVIEW OF MTC CONCRETE COMPRESSIVE STRENGTH DATA FOR 1985

By

S. Cripps

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS

Engineering Materials Office

Concrete Section

April 1986

Table of Contents

	Page
1. Introduction	1
2. Results	1
3. Summary	10
Appendix A - Summary of 28-day Compressive Strength Test Results	

LIST OF TABLES

2-1 Summary of Tests by Region	2
2-2 Summary of Tests by Region (Non-Slag Cement)	2
2-3 Summary of Tests by Region (Slag Cements)	3
2-4 Summary of Tests by Region (Latex Modified Concrete)	3

LIST OF FIGURES

2.1 Summary of Tests by Contract - 20 MPa, Non-Slag Cement	4
2.2 Summary of Tests by Contract - 20 MPa, Slag Cement	6
2.3 Summary of Tests by Contract - 25 MPa, Non-Slag Cement	6
2.4 Summary of Tests by Contract - 30 MPa, Non-Slag Cement	7
2.5 Summary of Tests by Contract - 30 MPa, Slag Cement	8
2.6 Summary of Tests by Contract - 30 MPa, Latex Modified Concrete	8
2.7 Summary of Tests by Contract - 35 MPa, Non-Slag and Slag Cement	8

1. INTRODUCTION

Concrete placed on Ministry contracts must meet the requirements of OPSS 1350 in the Ontario Provincial Standard Specifications. One of the requirements of acceptance is based on the results of 28-day compressive strength tests as specified in section 1350.08.01.05 of the Standards. Copies of the 28-day compressive strength tests from throughout the Province are forwarded to the Concrete Section of the Engineering Materials Office in Downsview. These results are placed on a micro-computer for the purposes of reviewing the results and to provide contract, regional and provincial summaries. The test results are not used by the Concrete Section for acceptance or rejection purposes.

The purpose of this report is to provide a summary and review of 28-day compressive strength test results from Ministry contracts throughout Ontario in 1985. The summary includes test results of all concrete classes from 20 to 35 MPa including latex modified concrete. Not included in the report are results of tests on tremie concrete, grout cubes or concrete placed on maintenance and municipal contracts. Where a contract commenced in 1984 and was completed in 1985, only the test results from concrete placed in 1985 are included in the report.

2. RESULTS

In the following summary of results, a test is defined as the average of two standard 150 x 300 mm cylinders as stated in OPSS 1350. The Ontario Provincial Standard Specifications require that for concrete to conform to the specified nominal minimum 28-day strength, the following requirements are met:

i) The average of all groups of three consecutive strength tests shall be equal to a greater than the specified strength.

ii) No individual strength test shall be more than 3.5 MPa below the specified strength.

However, for the purpose of this report only, the terms "pass" and "fail" has been used. The "pass" term has been used to indicate that the result of a single compressive strength test (not three consecutive tests) is greater than or equal to the specified strength, and the "fail" term has been used to indicate that the result of a single compressive strength test is less than the specified strength.

Table 2.1 shows the total number of tests performed in each of the five regions as well as the percentage of tests that passed and failed:

TABLE 2.1: SUMMARY OF TESTS BY REGION

Region	Number of Tests	% Pass	% Fail
Central	1824	94.7	5.3
Southwestern	289	91.0	9.0
Eastern	503	86.9	13.1
Northwestern	140	93.6	6.4
Northern	339	78.8	21.2
All Regions	3095	91.3	8.7

In Tables 2.2, 2.3 and 2.4 the tests in each region are broken down by concrete with no slag cement, concrete containing slag cement and latex modified concrete respectively:

TABLE 2.2: SUMMARY OF TESTS BY REGION (NON-SLAG CEMENT)

	20 MPa		25 MPa		30 MPa		35 MPa	
Region	# Tests	% Pass	# Tests	% Pass	# Tests	% Pass	# Tests	% Pass
Central	254	100	28	96.4	440	93.2	164	97.6
Southwestern	112	100	43	100	83	74.7	12	83.3
Eastern	132	97.7	22	90.9	304	81.9	-	-
Northwestern	32	100	-	-	64	89.1	-	-
Northern	78	98.7	25	100	229	72.1	-	-
All Regions	608	99.3	118	97.5	1120	84.2	176	96.6

TABLE 2.3: SUMMARY OF TESTS BY REGION (SLAG CEMENTS)

Region	20 MPa # Tests	20 MPa % Pass	25 MPa # Tests	25 MPa % Pass	30 MPa # Tests	30 MPa % Pass	35 MPa # Tests	35 MPa % Pass
Central	173	100	11	100	597	96.3	97	95.9
Southwestern	6	100	2	100	23	95.7	-	-
Eastern	-	-	-	-	-	-	-	-
Northwestern	8	100	-	-	36	94.4	-	-
Northern	-	-	-	-	-	-	-	-
All Regions	187	100	13	100	656	96.2	97	95.9

TABLE 2.4: SUMMARY OF TESTS PER REGION (LATEX MODIFIED CONCRETE)

Region	# Tests	% Pass
Central	60	41.7
Southwestern	8	75.0
Eastern	45	86.7
Northwestern	-	-
Northern	7	0.0
All Regions	120	58.3

Figure 2.1 through 2.7 provide a graphical summary of the test results by concrete class and type (non-slag, slag, latex modified). These figures show the mean and standard deviation of all test results by contract for each concrete class in the five regions. For clarity purposes, contracts that contained less than two test results for a given concrete class were not shown in these figures. Also, actual contract numbers have been replaced with a series of numbers beginning at "1".

Figure 2.1 presents the test results for 20 MPa concrete containing no slag cement. In general, the results show that there is little problem in achieving compressive strength, although one set of results had a mean strength of 20.7 MPa. Standard deviations in this figure range up to 6.39 MPa (contract 7, Southwestern Region), indicating inconsistencies in either production or testing. However, this same contract achieved a high mean compressive strength which would indicate that strength problems were not encountered in spite of the large variance in test results.

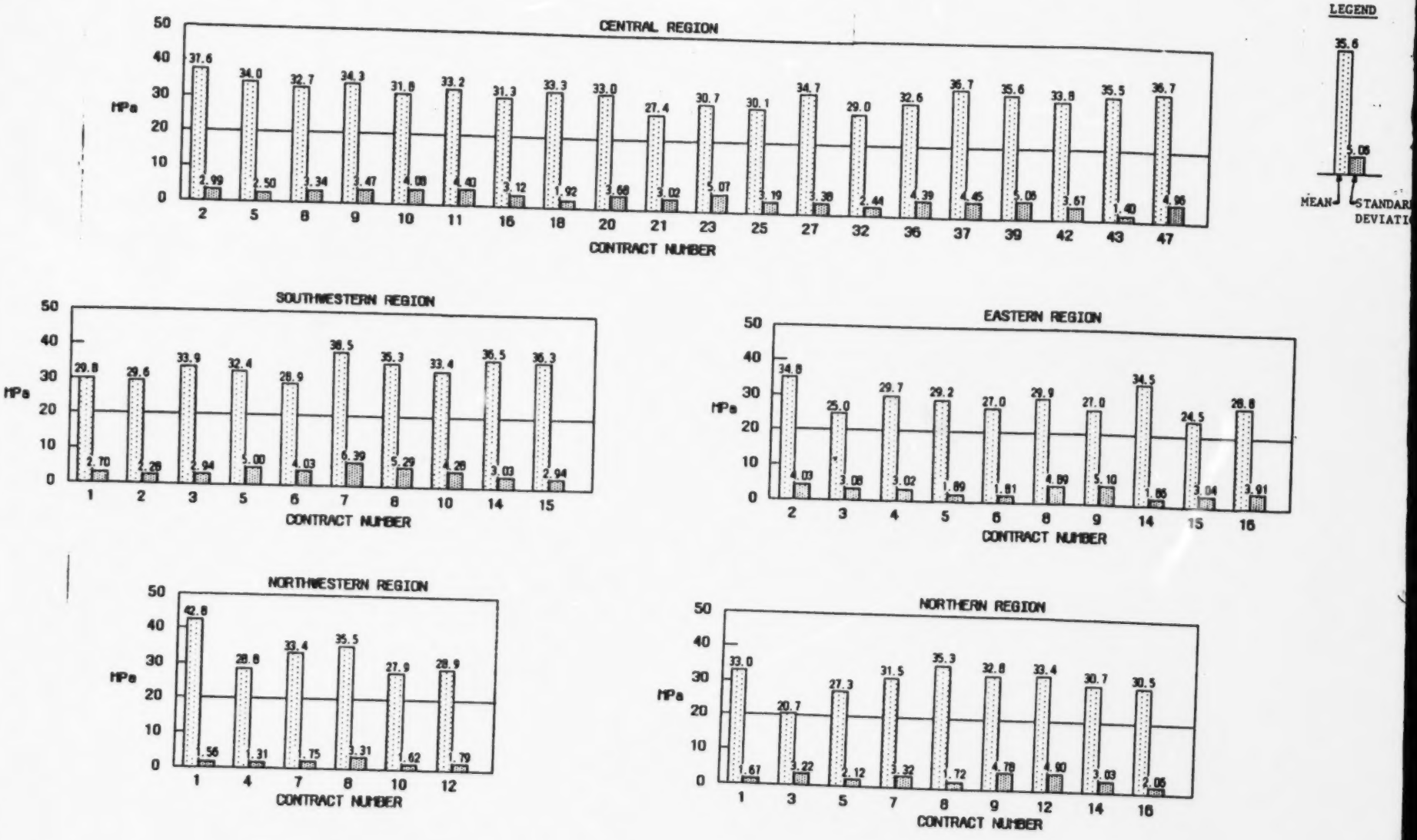

FIGURE 2.1 SUMMARY OF TESTS BY CONTRACT - 20 MPa, NON-SLAG CEMENT

Figure 2.2 summarizes test results for 20 MPa class concrete containing slag cement. From this figure, it is apparent that the use of slag cement as a partial (up to 25%) replacement for normal portland cement is limited primarily to Central Region. The figure shows a range of means from 31.7 MPa up to 37.9 MPa which indicates good compressive strengths are generally achieved with 20 MPa class concrete containing slag cement.

Figure 2.3 presents the test results for 25 MPa class concrete containing no slag cement. This class of concrete is used infrequently on MTC contracts, although this figure indicates that no problems were encountered in achieving good compressive strength. The test results for 25 MPa concrete containing slag cement have not been included in this series of figures because there are very few results. However, Appendix A contains the statistics in all test results throughout the province in tablular form.

The summary of test results for 30 MPa class concrete containing no slag cement are presented in Figure 2.4. The means range from a low of 26.9 MPa up to a high of 42.2 MPa. There are numerous contracts shown in this figure which have mean strengths very close to 30 MPa, with high standard deviations, indicating serious quality problems are present in concrete placed on Ministry contracts. This problem is not quite as evident in 30 MPa class concrete containing slag cement as shown in Figure 2.5. Although there are considerably fewer contracts in this figure, the results are generally more favourable.

Figure 2.6 summarized tests on 30 MPa latex modified concrete (LMC). This type of concrete is used for bridge deck overlays and is produced on site by a mobile mixer. It is apparent that problems were encountered in achieving acceptable compressive strengths and it is believed that the primary cause for low strength was due to sub-standard materials (latex modifier). Latex modified concrete is used primarily because of its impermeability and durability characteristics, and although the Concrete Section is concerned about the results, compressive strength is not of prime importance to the integrity of this overlay.

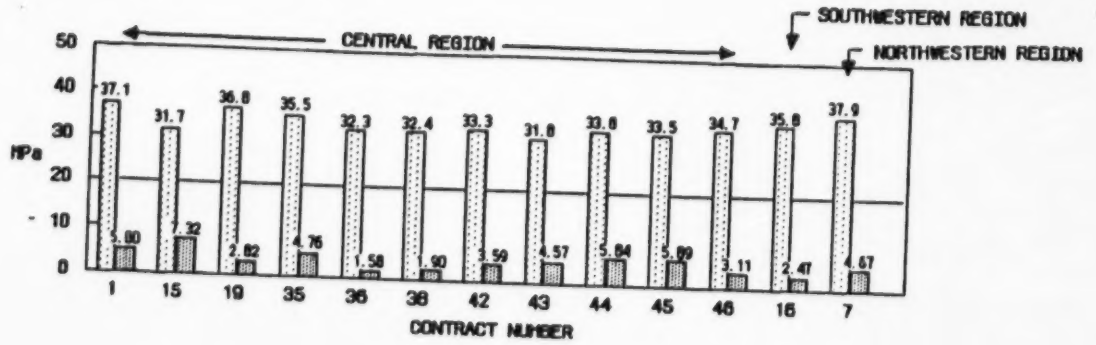

FIGURE 2.2 SUMMARY OF TESTS BY CONTRACT - 20 MPa, SLAG CEMENT

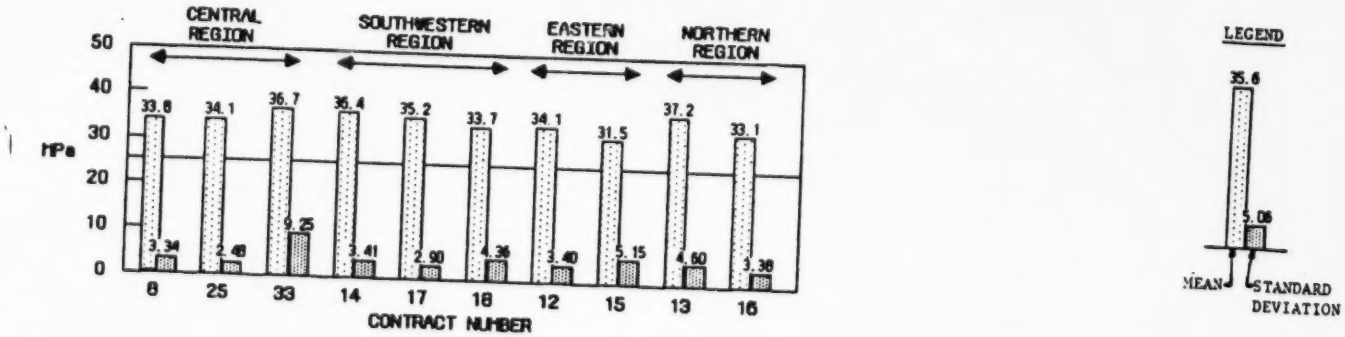

FIGURE 2.3 SUMMARY OF TESTS BY CONTRACT - 25 MPa, NON-SLAG CEMENT

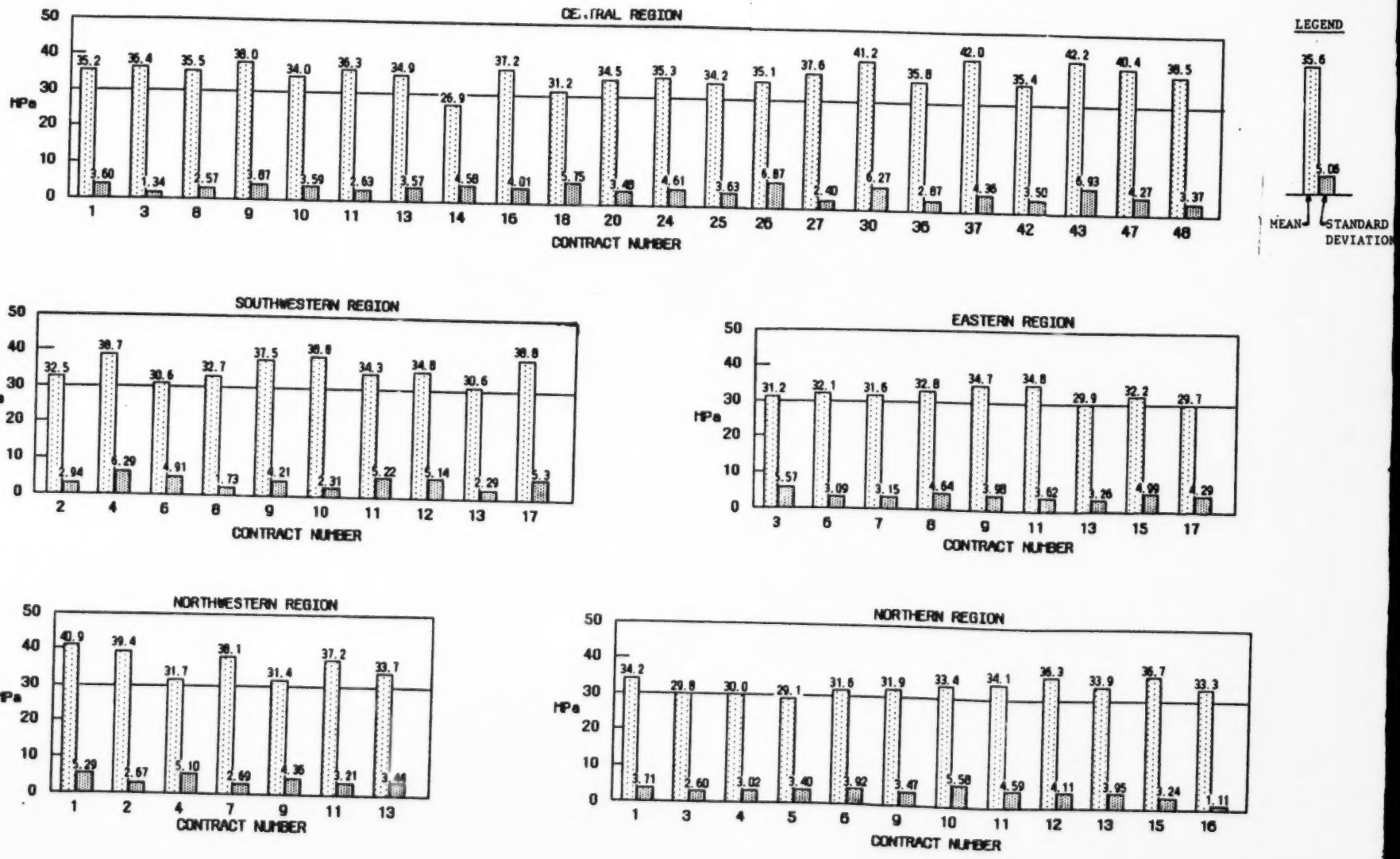

FIGURE 2.4 SUMMARY OF TESTS BY CONTRACT - 30 MPa, NON-SLAG CEMENT

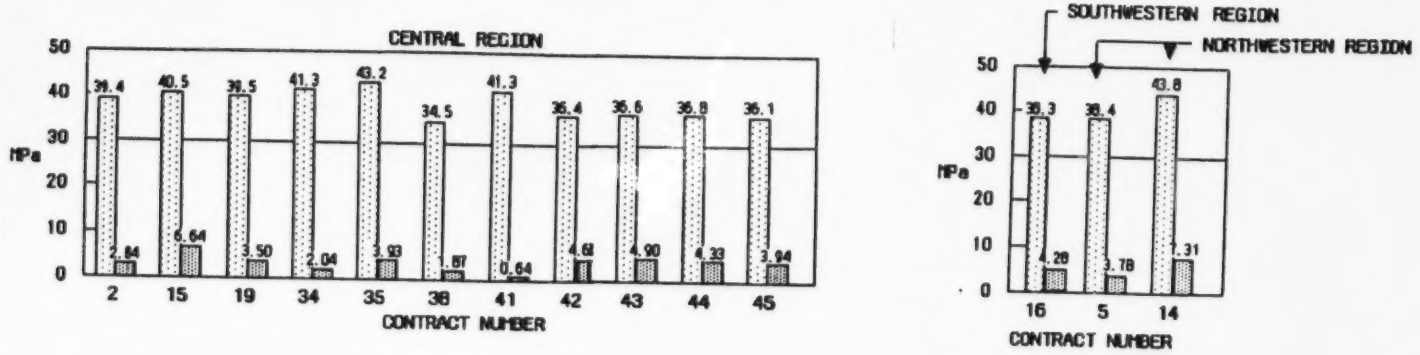

FIGURE 2.5 SUMMARY OF TESTS BY CONTRACT - 30 MPa, SLAG CEMENT

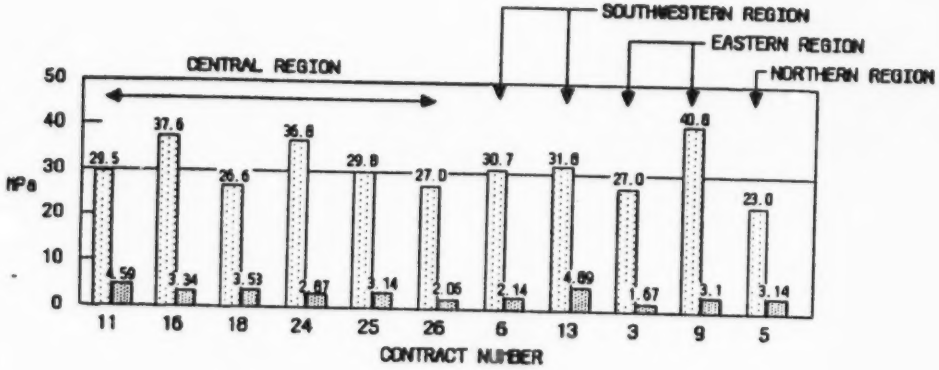

FIGURE 2.6 SUMMARY OF TESTS BY CONTRACT - 30 MPa, LATEX MODIFIED CONCRETE

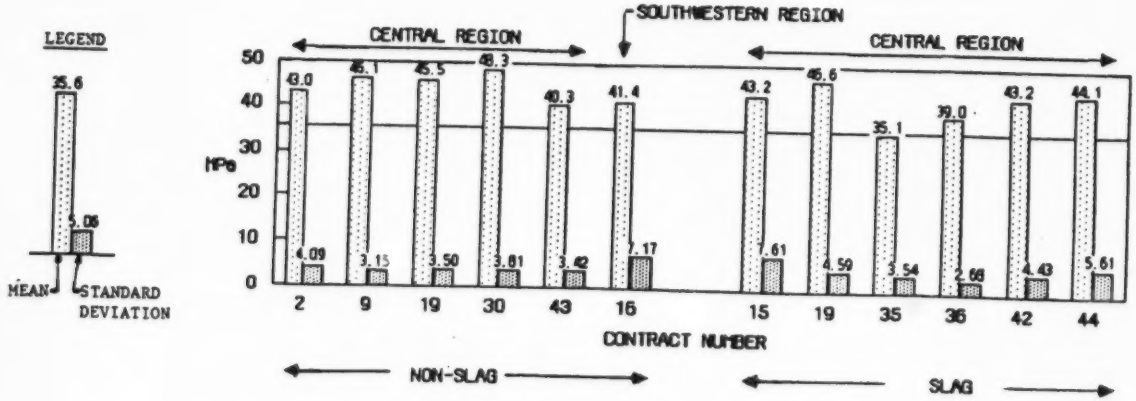

FIGURE 2.7 SUMMARY OF TESTS BY CONTRACT - 35 MPa, NON-SLAG and SLAG CEMENT

Figure 2.7 presents a summary of results of 35 MPa class concrete, both non-slag and slag mixes. Generally, the results were good, although two of the low results occured in concrete containing slag-cement.

3. SUMMARY

The results of concrete compressive strength tests from Ministry contracts has been summarized in graphical form in Figures 2.1 through 2.7 and in tabular form in Appendix A.

Low compressive strengths were most evident in 30 MPa class concrete containing no slag cement and with latex modified concrete. In total, 3095 tests results were included in the summary, of which 91.3 percent test results were greater than or equal to the specified strength.

APPENDIX A

Summary of 28-Day Compressive Strength Tests Results

SUMMARY OF 28-DAY COMPRESSIVE STRENGTH TEST RESULTS - CENTRAL REGION

CON-TRACT	20 MPa			20 MPa SLAG			25 MPa			25 MPa SLAG			30 MPa			30 MPa SLAG			LATEX MOD			35 MPa			35 MPa SLAG		
	# TESTS	MEAN	ST DEV	# TESTS	MEAN	ST DEV	# TESTS	MEAN	ST DEV	# TESTS	MEAN	ST DEV	# TESTS	MEAN	ST DEV	# TESTS	MEAN	ST DEV	# TESTS	MEAN	ST DEV	# TESTS	MEAN	ST DEV	# TESTS	MEAN	ST DEV
1				12	37 1	5 00							8	35 2	3 60												
2	16	37 6	2 99													213	39 4	2 84				92	43 0	4 09			
3													3	36 4	1 34												
4							1	34 3	-																		
5	10	34 0	2 50										2	33 4	2 55												
6	2	36 1	2 55										2	43 6	71												
7													6	35 5	2 57												
8	7	32 7	3 34				5	33 8	3 34				47	38 0	3 87							11	46 1	3 15			
9	17	34 3	3 47										12	34 0	3 59												
10	10	31 8	4 08				1	32 2	-																		
11	14	33 2	4 40										19	36 3	2 63				4	29 5	4 59						
12													1	36 1	-												
13													20	34 9	3 57												
14	2	23 1	1 20										8	26 9	4 58												
15				8	31 7	7 32				1	44 5	-				35	40 5	6 64							14	43 2	7 61
16	5	31 3	3 12				1	28 7	-				34	37 2	4 01				10	37 6	3 34						
17				2	35 2	71													17	26 6	3 53	1	50 1	-			
18	3	33 3	1 92										19	31 2	5 75	54	39 5	3 50				27	45 5	3 50	40	46 6	4 59
19				29	36 8	2 82																					
20	36	33 0	3 68										32	34 5	3 46												
21	10	27 4	3 02																								
22	2	30 7	92																								
23	8	30 7	5 07										4	35 3	4 61				3	36 8	2 87						
24	1	32 3	-										18	34 2	3 63				14	29 8	3 14						
25	4	30 1	3 19				10	34 1	2 46				5	35 1	6 87				11	27 0	2 06						
26													6	37 6	2 40												
27	4	34 7	3 38																								
28	1	28 9	-																								
29	2	29 4	3 82										17	41 2	6 27							20	46 3	3 81			
30																											
31	2	26 0	4 88				2	34 8	4 03				1	40 7	-				1	27 3	-						
32	9	29 0	2 44																								
33	1	40 4	-				7	36 7	9 25																		
34				2	33 8	4 17										5	41 3	2 04							3	35 1	3 54
35				26	35 5	4 76										10	43 2	3 93							10	39 0	2 68
36	36	32 6	4 39	5	32 3	1 58							17	35 8	2 87	2	39 1	35									
37	34	36 7	4 45				1	43 2	-				61	42 0	4 36												
38				4	32 4	1 90				2	31 2	3 82				3	34 5	1 87									
39	4	35 6	5 06																								
40													2	42 6	2 33												
41				1	34 1	-										5	41 3	64									
42	7	33 8	3 67	10	33 3	3 59				1	32 1	-	28	35 4	3 50	191	36 4	4 62							5	43 2	4 43
43	3	35 5	1 40	38	31 8	4 57							28	42 2	6 93	31	36 6	4 90				13	40 3	3 42			
44				13	33 8	5 84										26	36 8	4 33							25	44 1	5 61
45				11	33 5	5 89				7	38 3	5 64				20	36 1	3 94									
46				12	34 7	3 11										2	41 0	3 39									
47	4	36 7	4 96										28	40 4	4 27												
48													12	38 5	3 37												

SUMMARY OF 28-DAY COMPRESSIVE STRENGTH TEST RESULTS - SOUTHWESTERN REGION

CON-TRACT	20 MPa			20 MPa SLAG			25 MPa			25 MPa SLAG			30 MPa			30 MPa SLAG			LATEX MOD.			35 MPa			35 MPa SLAG		
	• TESTS	MEAN	ST DEV	• TESTS	MEAN	ST DEV	• TESTS	MEAN	ST DEV	• TESTS	MEAN	ST DEV	• TESTS	MEAN	ST DEV	• TESTS	MEAN	ST DEV	• TESTS	MEAN	ST DEV	• TESTS	MEAN	ST DEV	• TESTS	MEAN	ST DEV
1	14	29 8	2 70																								
2	10	29 6	2 28																								
3	8	33 9	2 94										4	32 5	2 94												
4																											
5	6	32 4	5 00										6	38 7	6 29												
6	53	28 9	4 03																								
7	4	36 5	6 39										31	30 6	4 91				4	30 7	2 14						
8	5	35 3	5 29																								
9													7	32 7	1 73												
10	4	33 4	4 28										6	37 5	4 21												
11													4	38 8	2 31												
12													9	34 3	5 22												
13	1	28 8	-				2	34 3	1 77				6	34 8	5 14												
14	3	36 5	3 03										3	30 6	2 29												
15	4	36 3	2 94				30	36 4	3 41				2	35 4	3 75				4	31 8	4 89						
16				6	35 8	2 47				2	42 9	2 55				23	38 3	4 28				12	41 4	7 17			
17							8	35 2	2 90				5	38 8	5 30												
18							3	33 7	4 36																		

SUMMARY OF 28-DAY COMPRESSIVE STRENGTH TEST RESULTS - EASTERN REGION

CON-TRACT	20 MPa			20 MPa SLAG			25 MPa			25 MPa SLAG			30 MPa			30 MPa SLAG			LATEX MOD			35 MPa			35 MPa SLAG		
	• TESTS	MEAN	ST DEV	• TESTS	MEAN	ST DEV	• TESTS	MEAN	ST DEV	• TESTS	MEAN	ST DEV	• TESTS	MEAN	ST DEV	• TESTS	MEAN	ST DEV	• TESTS	MEAN	ST DEV	• TESTS	MEAN	ST DEV	• TESTS	MEAN	ST DEV
1													1	36 4	-												
2	13	34 8	4 03																								
3	5	25 0	3 06										4	31 2	5 57				6	27 0	1 67						
4	7	29 7	3 02																								
5	5	29 2	1 89																								
6	5	27 0	1 81																								
7													78	32 1	3 09												
8	10	29 9	4 89										15	31 6	3 15												
9	38	27 0	5 10										15	32 8	4 64												
10	1	32 7	-				2	37 1	1 34				153	34 7	3 98				39	40 8	3 10						
11	2	35 7	65																								
12													5	34 8	3 62												
13							5	34 1	3 40																		
14	3	34 5	1 86				1	31 2	-				9	29 9	3 26												
15	3	24 5	3 04				2	40 3	07																		
16	40	28 8	3 91				11	31 5	5 15				8	32 2	4 99												
17																											
18							1	36 7	-				14	29 7	4 29												
19													2	35 1	1 77												

SUMMARY OF 28-DAY COMPRESSIVE STRENGTH TEST RESULTS - NORTHWESTERN REGION

CON-TRACT	20 MPa			20 MPa SLAG			25 MPa			25 MPa SLAG			30 MPa			30 MPa SLAG			LATEX MOD			35 MPa			35 MPa SLAG		
	* TESTS	MEAN	ST DEV	* TESTS	MEAN	ST DEV	* TESTS	MEAN	ST DEV	* TESTS	MEAN	ST DEV	* TESTS	MEAN	ST DEV	* TESTS	MEAN	ST DEV	* TESTS	MEAN	ST DEV	* TESTS	MEAN	ST DEV	* TESTS	MEAN	ST DEV
1	4	42 8	1 56										8	40 9	5 29												
2	2	31 2	49										14	39 4	2 67												
3				7	37 9	4 67																					
4	3	28 8	1 31										8	31 7	5 10												
5				1	35 7	-										27	38 4	3 78									
6	2	28 3	2 76																								
7	4	33 4	1 75										6	38 1	2 69												
8	5	35 5	3 31																								
9													8	31 4	4 36												
10	4	27 9	1 62																								
11													11	37 2	3 21												
12	8	28 9	1 79																								
13													9	33 7	3 44												
14																9	43 8	7 31									

SUMMARY OF 28-DAY COMPRESSIVE STRENGTH TEST RESULTS - NORTHERN REGION

CON-TRACT	20 MPa			20 MPa SLAG			25 MPa			25 MPa SLAG			30 MPa			30 MPa SLAG			LATEX MOD			35 MPa			35 MPa SLAG		
	* TESTS	MEAN	ST DEV	* TESTS	MEAN	ST DEV	* TESTS	MEAN	ST DEV	* TESTS	MEAN	ST DEV	* TESTS	MEAN	ST DEV	* TESTS	MEAN	ST DEV	* TESTS	MEAN	ST DEV	* TESTS	MEAN	ST DEV	* TESTS	MEAN	ST DEV
1	3	33 0	1 67										10	34 2	3 71												
2													1	30 6	-												
3	4	20 7	3 22										26	29 8	2 60												
4													11	30 0	3 02												
5	8	27 3	2 12										22	29 1	3 40				7	23 0	3 14						
6	2	32 7	3 54										5	31 6	3 92												
7	8	31 5	3 32																								
8	6	35 3	1 72										2	36 8	49												
9	23	32 8	4 78										65	31 9	3 47												
10													36	33 4	5 56												
11													21	34 1	4 59												
12	4	33 4	4 90										3	36 3	4 11												
13							10	37 2	4 60				9	33 9	3 95												
14	5	30 7	3 03																								
15													8	36 7	3 24												
16	15	30 5	2 06				15	33 1	3 38				7	33 3	1 11												
17													1	29 9	-												